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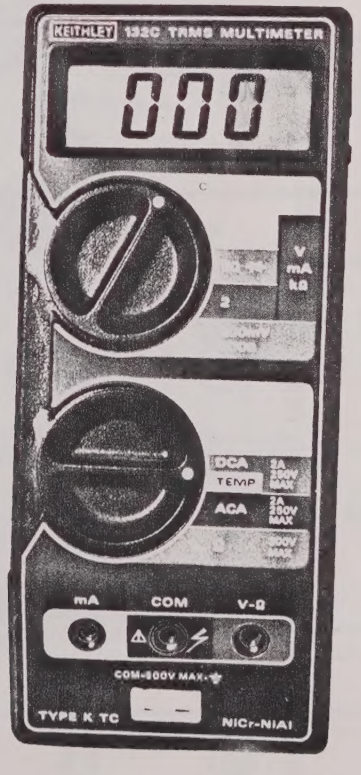
KEITHLEY

Model 132C and 132F
TRMS Digital Multimeter
Instruction Manual



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WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace, at our option, any instrument thereof which, within a year from date of shipment, proves defective upon examination. We will pay local domestic surface freight costs. (NOTE: This warranty does not cover battery replacement or damage due to battery leakage.)

SERVICE POLICY

For Service on your Model 132C and 132 F TRMS Digital Multimeter, contact your local Keithley representative who will be able to give you immediate assistance in most cases. Complete repair and calibration facilities are maintained in the United States, West Germany, Great Britain, France, the Netherlands, Switzerland, and Austria. Information concerning the application, operation or service of your instrument may be directed to the applications engineer at any of the above locations.

SAFETY SYMBOLS AND TERMS

The symbol ⚠ on the instrument denotes that the user should refer to the operating instructions.

The symbol ⚡ on the instrument denotes that a high voltage may be present on the terminal(s).

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

The **CAUTION** used in this manual explains hazards that could damage the instrument.

SPECIFICATIONS

DC VOLTS

RANGE	RESOLUTION	ACCURACY (1 YEAR) ±(%rdg + digits) 18°-28°C
200mV	100 μV	
2 V	1mV	
20 V	10mV	±(0.25% + 1d)
200 V	100mV	
1000 V	1 V	

MAXIMUM ALLOWABLE INPUT: 1000V DC or peak AC non-switched, 750V peak switched.

INPUT RESISTANCE: 10MΩ.

NORMAL MODE REJECTION RATIO: Greater than 46dB at 50Hz, 60Hz.

COMMON MODE REJECTION RATIO: Greater than 100dB at DC, 50Hz and 60Hz (1kΩ unbalance).

TRMS AC VOLTS

RANGE	RESOLUTION	ACCURACY (1 YEAR) ±(%rdg + digits) 18°-28°C	FREQUENCY RANGE
200mV	100 μV		
2 V	1mV		
20 V	10mV	±(1% + 9d)	45Hz-500Hz
200 V	100mV		
750 V	1 V		

MAXIMUM ALLOWABLE INPUT: 1000V peak non-switched, 750V peak switched; continuous except 200mV range: 15s max above 300V.

INPUT IMPEDANCE: 10MΩ shunted by less than 100pF.

RESPONSE: True root mean square; AC coupled.

CREST FACTOR: Up to 3:1 allowable. Less than 2% additional error, 50Hzor 60Hz rectangular pulse train with crest factor of 3:1.

DC AMPS

RANGE	RESOLUTION	ACCURACY (1 YEAR) ±(%rdg + digits) 18°-28°C	MAXIMUM FULL SCALE VOLTAGE BURDEN
2mA	1 μA	±(0.75% + 1d)	0.25V
20mA	10 μA	±(0.75% + 1d)	0.25V
200mA	100 μA	±(1 % + 1d)	0.25V
2000mA	1mA	±(2 % + 1d)	0.7 V

OVERLOAD PROTECTION: 2A fuse (250V), externally accessible.

TRMS AC AMPS

RANGE	RESOLUTION	ACCURACY (1 YEAR) ±(%rdg + digits) 18°-28°C (45Hz-500Hz)	MAXIMUM FULL SCALE VOLTAGE BURDEN
2mA	1 μA	±(2% + 9d)	0.25V
20mA	10 μA	±(2% + 9d)	0.25V
200mA	100 μA	±(2% + 9d)	0.25V
2000mA	1mA	±(3% + 9d)	0.7 V

OVERLOAD PROTECTION: 2A fuse (250V), externally accessible.

RESPONSE: True root mean square, AC coupled.

CREST FACTOR: Less than 1.5% additional error, 50Hz or 60Hz rectangular pulse train with crest factor of 3:1 at 40% of full scale.

OHMS

RANGE	RESOLUTION	ACCURACY (1 YEAR) ±(%rdg + digits) 18°-28°C	FULL SCALE VOLTAGE
200 Ω	100mΩ	±(0.5% + 4d)	< 0.5V
2 kΩ	1 Ω	±(0.2% + 1d)	< 0.7V
20 kΩ	10 Ω	±(0.2% + 1d)	> 0.7V
200 kΩ	100 Ω	±(0.2% + 1d)	> 0.7V
20MΩ	10 kΩ	±(2 % + 1d)	> 0.7V

MAXIMUM OPEN CIRCUIT VOLTAGE: 1.5V.

MAXIMUM ALLOWABLE INPUT: 300V DC or rms.

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TEMPERATURE

MODEL	RANGE	RESOLUTION	ACCURACY (1 YEAR) 18°-28°C
132C	−20°C to 1370°C	1°C	±(3° + 1d) up to 150°C ±3% of reading over 150°C Chart correctable to ±1.5% of reading over 350°C
132F	0°F to 2000°F	1°F	±(5° + 2 digits) up to 225°F ±3% of reading over 225°F Chart correctable to ±1.5% of reading over 600°F

Accuracy includes NBS conformity, calibration stability, zero and reference junction, but not thermocouple errors.

SENSOR: Type K (NiCr-NiAl) (not included).

INPUT CONNECTIONS: Miniature TC connector.

OVERLOAD PROTECTION: 150V continuous, 300V momentary (10s).

GENERAL

DISPLAY: 0.6" LCD digits with decimal and polarity indications, low battery warning.

OVERRANGE INDICATION: 3 least significant digits blanked.

MAXIMUM COMMON MODE VOLTAGE: 500V peak.

OPERATING ENVIRONMENT: 0° to 50°C; less than 80% relative humidity up to 35°C. Linearly derate 3% RH/°C, 35°C to 50°C.

STORAGE ENVIRONMENT: −35° to 60°C; less than 90% relative humidity up to 35°C. Linearly derate 3% RH/°C, 35°C to 60°C.

TEMPERATURE COEFFICIENT: From 18° to 28°C: Included in accuracy specifications; from 0° to 18°C and 28° to 50°: Less than 0.1 × applicable accuracy specification per °C.

POWER: 9V alkaline or carbon-zinc battery (NEDA 1604).

BATTERY LIFE: 75 hours typical with carbon-zinc cells, 150 hours typical with alkaline cells.

BATTERY INDICATOR: Display indicates BAT when less than 10% of life remains.

DIMENSIONS, WEIGHT: 178mm long × 78mm wide × 42mm thick (7.0" × 3.1" × 1.6"). Net weight 370gm (13 oz.).

ACCESSORIES SUPPLIED: Battery, instruction manual, Model 1691 General Purpose Test Lead Set.

Specifications subject to change without notice.

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GENERAL INFORMATION

The Keithley Models 132C and 132F are handheld DMMs with six standard measuring functions, including DCV, ACV, DCA, ACA, resistance and temperature. The Model 132C provides temperature readout in °C, while the Model 132F gives temperature in °F. Otherwise, the two instruments are identical. Throughout the remainder of this manual, both instruments will be referred to as the Model 132 except for sections associated with temperature measurements.

The Model 132 has the following features.

1. TRMS Measurement Capability. The Model 132 is capable of accurate TRMS AC voltage and current measurements of complex, non-sinusoidal waveforms.
2. Temperature Measuring Capability. The instrument is supplied with a standard miniature thermocouple connector. The Model 132C measures temperature between −20°C and +1370°C. The Model 132F measures between 0°F and 2000°F.
3. Standard Measuring Functions. In its standard configuration, the Model 132 can make DC voltage measurements between 100μV and 1000V, AC voltage measurements between 100μV and 750V, DC and AC current measurements between 1μA and 2A, and resistance measurements in the range of 100mΩ to 20MΩ.
4. LCD Display. A large, 0.6 inch, easy to read LCD display also features low current drain for longer battery life.

MANUAL ADDENDA

The information presented in this manual was believed to be accurate at the time of printing. Any changes in the instrument which occur after the printing of this manual will be noted in an addendum included with the instrument. Be sure to take note of any changes before attempting to operate or service the instrument.

OPTIONAL ACCESSORIES

The following accessories may be used to enhance Model 132 capabilities. Contact your Keithley representative or the factory for information on obtaining accessories.

Model 1304 Soft Carrying Case and Stand for the Model 132.

Model 1306 Deluxe Case is a rugged carrying case that is large enough to accommodate the Model 132 plus various other articles such as a spare battery, manual, probes, etc.

Model 1600A High Voltage Probe extends the DMM to 40kV. It has a 1000:1 division ratio, which means that 1 volt on the DMM corresponds to 1 kilovolt.

Model 1651 50-Ampere Shunt allows current measurements to be made up to 50-amperes. It is a 0.001 ohm ±1% 4-terminal shunt. A 50-ampere current corresponds to 50 millivolts.

Model 1681A Clip-On Test Lead Set contains two leads, 1.2m (48 inches) long, terminated with banana plug and spring action clip-on probe.

Model 1682A RF Probe allows voltage measurements from 100kHz to 250MHz with the Model 132.

Model 1683 Universal Test Lead Kit consists of two test leads, 1.2m (48 inches) long with 12 screw-in tips—2 banana plugs, 2 spade lugs, 2 alligator clips with boots, 2 needle tips with chucks and 4 heavy-duty tip plugs.

Model 1685 Clamp-On AC Current Probe measures AC current by clamping onto a single conductor. Interruption of the current path is unnecessary. The Model 1685 detects current by sensing magnetic field produced by current.

Model 1691 General Purpose Test Lead Set consists of two .91m (36 inches) test leads with probe tips terminated in banana plugs.

Model 8700 Carrying Case With Belt Clip & Holster for the Model 8714A Probe.

TEMPERATURE PROBES AND SENSORS

Model 8711A Thermocouple Kit includes Model 8712 Thermocouple Sensor, 6m (20') of AWG #24 type K duplex TC wire, miniature TC plug/jack, standard TC plug/jack.

Model 8712 Thermocouple Sensor consists of a three foot TC wire sensor that has a beaded thermocouple junction.

Model 8713 Immersion Probe for liquid and general purpose applications up to 900°C.

Model 8714A Penetration Probe with coiled cord for measurements of soft and semi-frozen solids.

Model 8715 Surface Probe for measurement of flat surfaces of solids.

Model 8716 Air/Gas Probe Exposed junction within protective shroud responds to ambient temperature while shielded from incident radiation.

Model 8717 Hypodermic Probe Miniature junction responds with one second time constant. All stainless steel construction is suitable for food industry, biological, and chemical applications.

PREPARATION FOR USE

Carefully unpack the Model 132 from its shipping carton and inspect for any obvious signs of physical damage. Report any damage to the shipping agent at once. The following items are included with every Model 132 shipment:

1. Model 132 DMM.
2. Model 132 Instruction Manual
3. Test Leads.
4. 9V battery (NEDA 1604).
5. Additional accessories as ordered.

BATTERY INSTALLATION/REPLACEMENT

A 9V battery is supplied with the Model 132, but it is not installed to avoid possible damage due to leakage during storage or shipment. To install or replace the battery, proceed as follows.

WARNING

Turn the Model 132 off and disconnect the input probes before replacing the battery. Put the cover back into place on the battery compartment before resuming use of the instrument.

Remove the cover from the battery compartment by sliding it off in the direction of the arrow located on the battery cover. The battery connector snaps on and off the terminals of the battery. Improper installation of the battery will cause the connecting wires to be severed by excess strain. Proper installation requires that the battery be positioned in such a manner (see drawing) that the leads protruding from the boot of the battery connector face toward the outside of the battery compartment. If the instrument is going to be stored for a long period of time or in a high temperature environment, remove the battery to prevent leakage damage.

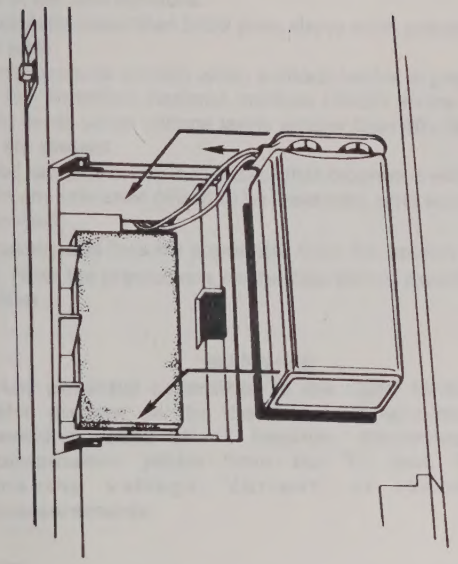
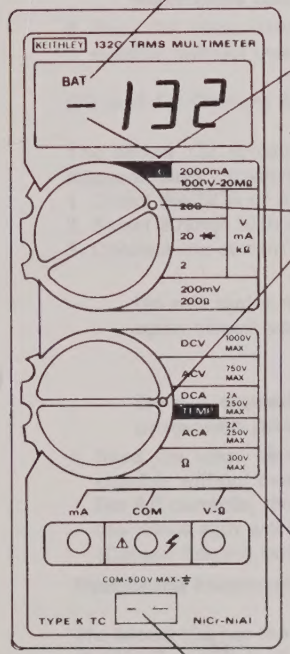


Figure 1. Battery Installation

OPERATION

The following paragraphs describe the basic operating procedure for making DCV, ACV, DCA, ACA, resistance, and temperature measurements. Also included is information for making diode tests. To minimize potential hazards, it is recommended that the information presented here be reviewed carefully before attempting to operate the instrument.



Low Battery Indicator shows when less than 10% of battery life remains.

Minus Sign indicates negative values. Plus sign is implied.

Overrange condition indicated by leading "1" followed by blanked digits.

Power on/off switch (on side of instrument.)

Function and Range Switches

DCV—200mV, 2V, 20V, 200V, or 1000V.

ACV—200mV, 2V, 20V, 200V, or 1000V.

NOTE: 750V AC is maximum allowable AC input.

DCA—2mA, 20mA, 200mA, or 2000mA.

ACA—2mA, 20mA, 200mA, or 2000mA.

Ω —200Ω, 2kΩ, 20kΩ, 200kΩ, or 20MΩ.

Temperature—TEMP and °C (Model 132C) or °F (Model 132F).

Input Jacks

COM, V-Ω—For all voltage and resistance measurements.

COM, mA—For all current measurements.

Thermocouple Input—For temperature measurements with a suitable probe.

Figure 2. Control Layout

Safety Precautions

1. Do not exceed the instrument's maximum allowable inputs as defined in the specifications.
2. Do not apply more than 500V peak above earth ground to the COM input jack.
3. Exercise extreme caution when a shock hazard is present at its input. The American National Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS or 42.4V peak are present.
4. A good safety practice is to expect that hazardous voltages are present in any unknown circuit to be measured, until actual conditions are verified.
5. The battery and fuse are accessable from the bottom of the instrument. Note the precautions on the case before installing or replacing either.

WARNING

Any potential connected to the COM terminal is also present on the thermocouple terminals. To avoid possible shock hazards, disconnect the temperature probe from the TC jack before making voltage, current, or resistance measurements.

DC Voltage Measurements

The Model 132 can make DC voltage measurements between 100μV and 1000V. Proceed as follows:

1. Place the instrument in the DCV mode with the function switch.
2. Select a range consistent with the expected voltage. If in doubt, use the 1000V range until the actual voltage level is established.
3. Connect the voltage source to the COM and V-Ω terminals.

CAUTION

Do not exceed 1000V between the COM and V-Ω terminals.

4. Read the value directly from the display. Use the lowest possible range without overranging the instrument for the best accuracy. A leading minus sign will appear if the potential at the V-Ω terminal is negative with respect to the COM terminal.

AC Voltage Measurements

The Model 132 is capable of TRMS AC voltage measurements in the range of 100μV to 750V. Proceed as follows:

1. Select the ACV mode with the function switch.
2. Place the instrument on a range suitable for the expected voltage.
3. Connect the AC voltage source to the V-Ω and COM terminals.

CAUTION

Do not exceed 750V RMS, 1000V peak between the V-Ω and COM terminals when the instrument is in the AC mode. This means with CF=3:1 the maximum RMS value is 333V.

4. Read the value directly from the display. Use the lowest range possible without overranging the display for the best accuracy.

DC and AC Current Measurements

The Model 132 is capable of making DC and TRMS AC current measurements between 1μA and 2A (2000mA). Proceed as follows:

1. Select the DCA or ACA function as required.
2. Select a range high enough for the expected current.
3. Connect the current source to the mA and COM terminals.

WARNING

Do not make measurements in circuits where the open circuit voltage is greater than 250V.

CAUTION

Do not exceed a 2A input current or the internal protection fuse will blow.

4. Read the value directly from the display. Use the lowest range possible without overranging the instrument for the best accuracy. For AC currents, the TRMS value will be shown. For DC currents, the minus sign will appear when a negative current is measured. (Current flowing out of the mA jack.)

Resistance Measurements

The Model 132 has the ability to measure resistance values from a low of 100mΩ to a high of 20MΩ. Proceed as follows:

1. Switch the function switch to the Ω position.
2. Select an appropriate resistance range; use the lowest possible range for the best accuracy.
3. Connect the resistance to be measured to the V-Ω and COM terminals.

CAUTION

Do not exceed an input voltage of 350V DC or RMS or the instrument may be damaged.

4. Read the resistance value directly from the display. The maximum open circuit output voltage is 1.5V.

Diode Test

The Model 132 may be used to quickly check semiconductor junctions on the 20kΩ range. Proceed as follows:

1. Select the 20kΩ range with the function and range switches. The diode symbol next to the 20 on the range scale is a reminder that diode checks should be made on that range.
2. To forward bias the diode junction, connect the anode to the V-Ω terminal and connect the cathode to the COM terminal (the V-Ω terminal is positive with respect to the COM terminal).
3. With the diode forward biased, the display should show an on-range reading. If the reading is very low (almost 0Ω) the diode is probably shorted. If the reading is very high (overrange) the diode is probably open.
4. Reverse the connections so that the diode is reverse biased. With the diode biased in this manner, an overrange condition shows that the diode is probably good, assuming the proper conditions were observed in step 3. An on-range condition shows a low reverse resistance, indicating the diode is probably bad.

Temperature Measurement

The Model 132 can be used for making temperature measurements by connecting a thermocouple to the miniature TC jack. Proceed as follows:

1. Connect a type K (NiCr-NiAl) thermocouple to the TC jack on the instrument. See the accessories section for recommended temperature probes and sensors.

CAUTION

Do not exceed 150V continuous, 300V momentary (no more than 10 seconds) between the TC jack terminals or instrument damage may occur.

WARNING

Disconnect other test leads from the instrument before connecting the temperature probe. The TC input jack and COM terminals are internally connected; any potential connected to one terminal will appear at the other.

2. Place the range switch in the °C position (Model 132C) or °F position (Model 132F).
3. Place the function switch in the TEMP position.
4. Place the probe or thermocouple tip on or in the material to be measured and take the temperature reading directly from the display. The reading is in °C (Model 132C) or °F (Model 132F).

NOTE

The Model 132 is designed to automatically sense when a thermocouple is plugged into the TC jack; the display will show 000 when no thermocouple is connected.

Advantages of TRMS AC Measurements

Most conventional handheld DMMs actually measure the average value of an input waveform but are calibrated to read the RMS equivalent of a sine wave. This poses no problems as long as the waveform being measured is a pure, low-distortion sine wave. For complex, non-sinusoidal waveforms, however, AC measurements made with an averaging type meter can be grossly inaccurate. The Model 132, because of its TRMS (True Root-Mean-Square) measuring capabilities, provides accurate AC measurements of a wide variety of input waveforms.

The RMS value of a pure sine wave is equal to 0.707 times its peak value. The average value of such a waveform is 0.637 times the peak value. Thus, an average-responding meter must be designed to incorporate a correction factor. This correction factor, F, can be found by dividing the RMS value by the average value as follows:

$$F = \frac{0.707}{0.637} = 1.11.$$

By automatically applying this correction factor to an averaged reading, a typical meter can be designed to give the RMS equivalent. This works fine as long as the waveform is a pure sine wave, but the ratios between RMS and average values of different waveforms is far from constant, and can vary considerably.

Table 1 shows a comparison of three common types of waveforms. For reference, the first waveform is an ordinary sine wave with a peak amplitude of 10V. The rectified average value of this voltage is 6.37V, while its RMS value is 7.07V. By applying the 1.11 correction factor to the average reading, it can be seen that both meters will give the same reading, resulting in no error in the averaging-type meter reading.

Table 1. Comparison of Average and TRMS Meter Readings

Waveform	Peak Value	Rectified Average Value	RMS Value	Average Responding Meter Reading	AC Coupled TRMS Meter Reading	Averaging Meter Percent Error
Sine +10 0	10V	6.37V	7.07V	7.07V	7.07V	0%
Half-wave Sine +10 0	10V	3.18V	3.86V	3.53V	3.86V	8.5%
Rectified Square Wave +10 0	10V	5V	5V	5.55V	5V	11%

The situation changes with the half-wave rectified sine wave. As before, the peak value of the waveform is 10V, but the average value drops to 3.18V. The RMS value of this waveform is 3.86V, but the average responding meter will give a reading of 3.53V (3.18 × 1.11). A similar situation exists for the rectified square wave, which has an average value of 5V and an RMS value of 5V. Here, the average responding meter gives a reading of 5.55V (5 × 1.11), while the Model 132 gives a TRMS reading of 5V.

Crest Factor

The crest factors of various waveforms are different since the peak-to-RMS ratios are variable. For example, the crest factor of an AC coupled rectangular pulse waveform is related to the duty cycle; as follows:

$CF = \sqrt{(T/t) - 1}$ (T = period, t = pulse width).

The Model 132 has an AC voltage crest factor rating of 3, which means the instrument will give an accurate reading of a rectangular pulse waveform with a duty cycle as low as 10%. The AC current crest factor capability is also 3 for an input current up to 40% of full range. For other allowable AC current factors, see Figure 3.

The AC voltage and current frequency ranges stated in the specifications give the sine wave response of the instrument. Since non-sinusoidal waveforms could have numerous harmonics above the frequency range of the instrument, variations in accuracy with complex waveforms are possible. For example, a 500Hz square wave pulse train contains not only a 500Hz fundamental, but also odd harmonics (1500Hz, 2500HZ, 3500Hz, etc.), which are above the frequency range of the Model 132. In general, measurements of non-sinusoidal waveforms will be more accurate if made in the lower part of the frequency measurement range of the instrument. For a 60Hz AC-coupled pulse train, with a crest factor of 3, less than 2% additional bandwidth error can be anticipated.

Figure 3. Allowable AC Amps Crest Factor for Less Than 1.5% Additional Error. (Error will be less for other types of waveforms.)

Temperature Error Compensation

With a standard K type thermocouple, the Model 132C is capable of temperature measurements in the range of −20°C to +1370°C. Similarly, the Model 132F temperature range is from 0°F to +2000°F.

Accuracy figures for these two instruments includes the nonlinearity of the thermocouple itself. Therefore, a correction table can be used to increase the overall accuracy.

Table 2 shows temperature correction factors that can be used with the Models 132C and 132F when making temperature measurements above 350°C (600°F) (thermocouple nonlinearity error is minimal between −20°C and 350°C as well as between 0°F and +600°F, so correction is not necessary within those ranges). To calculate the corrected reading, simply find the displayed Model 132C or 132F reading in the table and note the correction factor. Add or subtract the factor from the displayed reading to obtain the corrected temperature. For example, at 600°C, the correction factor is −10°C, resulting in a corrected reading of 590°C. Similarly, for the Model 132F, the correction factor at 1500°F is −28°F, resulting in a corrected temperature of 1472°F.

Table 2. Temperature Correction Factors

Model 132C Reading (°C)	Correction Factor (°C)	Model 132F Reading (°F)	Correction Factor (°F)
350-362	0	600-629	+1
363-395	−1	630-669	0
396-424	−2	670-705	−1
425-451	−3	706-738	−2
452-476	−4	739-768	−3
477-500	−5	769-796	−4
501-524	−6	797-823	−5
525-547	−7	824-850	−6
548-571	−8	851-875	−7
572-595	−9	876-900	−8
596-619	−10	901-924	−9
620-646	−11	925-948	−10
647-674	−12	949-971	−11
675-707	−13	972-995	−12
708-750	−14	996-1018	−13
751-912	−15	1019-1041	−14
913-950	−14	1042-1065	−15
951-978	−13	1066-1089	−16
979-1002	−12	1090-1113	−17
1003-1022	−11	1114-1138	−18
1023-1040	−10	1139-1163	−19
1041-1057	−9	1164-1190	−20
1058-1073	−8	1191-1217	−21
1074-1087	−7	1218-1247	−22
1088-1100	−6	1248-1278	−23
1101-1113	−5	1279-1313	−24
1114-1125	−4	1314-1354	−25
1126-1136	−3	1355-1404	−26
1137-1147	−2	1405-1495	−27
1148-1157	−1	1496-1566	−28
1158-1167	0	1567-1654	−27
1168-1176	+1	1655-1700	−26
1177-1185	+2	1701-1736	−25
1186-1194	+3	1737-1767	−24
1195-1202	+4	1768-1794	−23

Table 2. Temperature Correction Factors

Model 132C Reading (°C)	Correction Factor (°C)	Model 132F Reading (°F)	Correction Factor (°F)
1203-1211	+5	1795-1818	−22
1212-1218	+6	1819-1840	−21
1219-1226	+7	1841-1861	−20
1227-1233	+8	1862-1880	−19
1234-1240	+9	1881-1899	−18
1241-1247	+10	1900-1916	−17
1248-1254	+11	1917-1932	−16
1255-1260	+12	1933-1948	−15
1261-1267	+13	1949-1963	−14
1268-1278	+14	1964-1978	−13
1274-1279	+15	1979-1992	−12
1280-1285	+16	1993-2000	−11
1286-1291	+17		
1292-1297	+18		
1298-1302	+19		
1303-1308	+20		
1309-1313	+21		
1314-1318	+22		
1319-1324	+23		
1325-1329	+24		
1330-1334	+25		
1335-1339	+26		
1340-1343	+27		

SERVICING INFORMATION

This section contains information on fuse replacement, performance verification, calibration, and troubleshooting.

WARNING

The information presented in this section is intended only for qualified personnel. Disconnect the Model 132 test leads and turn off the power before replacing the battery or fuse. Replace all covers before connecting the instrument to potentially hazardous voltages.

Fuse Check

A 2A 250V fuse protects the instrument on the 2mA through 2000mA DC and AC current ranges. If neither current function is operational, the fuse is probably open. The fuse may be checked without removing it from the instrument as follows: With the instrument on the 2kΩ range, connect a test lead between the V-Ω and mA terminals. If the fuse is good, the display should show a reading of approximately .100. If the fuse is blown, the display will show an overrange condition. A reading other than .100 could indicate a problem with the input circuit. See the troublshooting section for details.

FUSE REPLACEMENT

The fuse is easily accessible through a compartment on the rear of the instrument. To remove the fuse cover, press outward in the same manner as when removing the battery compartment cover. Remove the fuse by pulling outward on the plastic tab that encircles the fuse body. Place the tab around the new fuse and snap it into place. Replace the fuse cover by reversing the procedure used to remove it.

CAUTION

Do not install a fuse with a larger rating than specified (2A fast blow) or instrument damage may occur, possibly voiding the warranty.

PERFORMANCE VERIFICATION

Performance verification may be performed upon receiving the instrument or if accuracy is suspect. Verification is performed by connecting

Table 3. Verification Summary

Equipment	Calibration Value	Model 132 Function and Range	Terminals	Required Reading
DC Voltage Calibrator ±0.005% tolerance	190.00mV 19.00V	200mV DC 20V DC	COM, V-Ω COM, V-Ω	189.4 to 190.6mV 18.94 to 19.06V
AC Calibrator ±0.075% tolerance	190.00mV, 500Hz 750.0V, 100Hz	200mV AC 1000V AC*	COM, V-Ω COM, V-Ω	187.2 to 192.8mV 733 to 767V
DC Current Calibrator ±0.05%	1.000A	2000mA DC	COM, mA	979 to 1021mA
10MΩ ±0.5% Resistance	10MΩ	20MΩ	COM, V-Ω	9.79 to 10.21MΩ
Ice Water Bath (See calibration section)	0°C** 32°F***	°C, TEMP °F, TEMP	Thermocouple Thermocouple	−.004° to +.004°C 25°F to 39°F

*CAUTION: Do not exceed 750V RMS input.
**Model 132C
***Model 132F

an accurate calibration source to the instrument and verifying that the display reading falls within the prescribed range as follows:

1. Perform the verification procedure at an ambient temperature between 18°C and 28°C. If the instrument has been stored at a temperature outside this range, allow sufficient time for its temperature to stabilize.
2. Connect the calibration source to the instrument as listed in Table 3. Make sure the Model 132 is switched to the appropriate function and range. Note that voltage and resistance verification is done by connecting the source to the V-Ω and COM terminals, and temperature calibration is achieved by connecting a suitable thermocouple, which is placed in an ice water bath. (See the calibration section for details.)
3. Verify that the reading is within the limits specified in Table 3. If the instrument is out of tolerance, refer to the calibration section for the correct procedure.

NOTE

If the instrument is still under warranty (less than 12 months since date of shipment), and it does not meet specifications, contact your Keithley representative or the factory to determine the correct course of action.

DISASSEMBLY INSTRUCTIONS

Place the unit face down on a bench or similar surface and remove the battery compartment cover. Disconnect and remove the battery; remove the two #4-40 × 1" retaining screws. Grasp the bottom cover at the input jack end, and, with a lifting forward motion, carefully remove the bottom cover, as shown in Figure 4. While removing the cover, feed the battery connector through the access hole in the bottom of the battery compartment.

The component side of the board is now exposed and the battery can be connected for troubleshooting and calibration. To read the display, some downward pressure may be necessary on the large 40 pin IC on the display end to make contact through the elastomer contact strip, which makes the connection between the PC board and the LCD display.

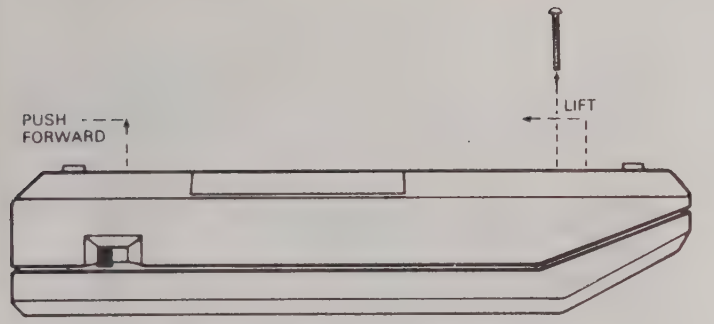


Figure 4. Rear Cover Removal

CAUTION

Avoid touching the PC board surfaces or ceramic input divider resistor network to prevent contamination which could degrade instrument performance.

Once the case retaining screws are removed, the PC board and LCD assemblies are no longer secured to the case top, so be careful not to allow them to fall out of the case or shift out of position during calibration.

To remove the printed circuit board, grasp the PC boad by the switch assembly and lift the PC board up until the input jacks become disengaged from the top cover. Some force on the TC input jack may be necessary to push it out of the case. The printed circuit board can now be removed from the front cover with a slight clockwise motion. The LCD assembly will remain in the top cover, but it will be loose, so be careful not to allow the assembly to fall out of the case.

The two switch knobs may be removed by pulling them off their respective shafts. The on-off switch cover should be removed and set aside to avoid losing it. The PC board shield may be removed, if necessary, by removing the two screws securing it to the PC board. The LCD assembly, along with the plastic contact strip, simply lifts out of the case.

To reassemble the Model 132, remove the fuse compartment cover and reverse the disassembly procedure.

WARNING

Be sure to replace the on-off switch cover. Common-mode voltage will be present on the switch, creating a possible hazard if the cover is not replaced.

NOTE

Proper alignment of the elastomer strip connector is necessary when installing the LCD display assembly. Make sure the conductor side of the contact strip is properly positioned against the plastic support of the LCD assembly.

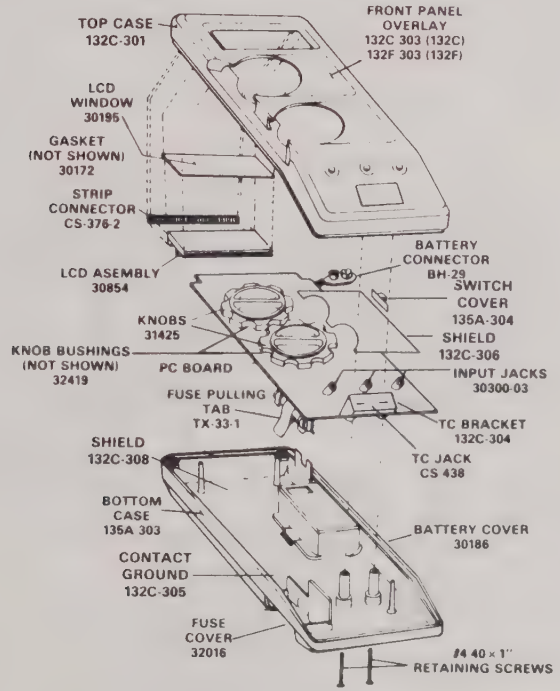


Figure 5. Model 132 Exploded View

CALIBRATION

Calibration should be performed yearly or whenever the instrument is known to be out of specification. Calibration should be done at an ambient temperature of 23 ±1°C with a relative humidity of less than 80%.

Calibration Equipment: DC Voltage Calibrator, 190mV DC, ±0.005%
AC Voltage Calibrator, 190mV, ±0.075%, 500Hz
Ice water bath in Dewars flask or thermos.
K-type TC wire terminated with standard miniature TC plug

Voltage Calibration

1. Remove rear cover using the procedure described in the disassembly instructions. Note that it is not necessary to remove the PC board from the case to perform calibration, but some slight pressure on the 40 pin IC on the display end may be necessary for the display to operate with the rear cover removed.
2. Remove the on-off switch cover to allow access to one of the calibration pots.
3. Connect a 190.00mV ±0.005%DC calibration voltage to the V-Ω and COM terminals. With the Model 132 on the 200mV DC range, adjust R108 (see Figure 6) for a reading of 190.0mV on the display.
4. Connect the AC calibrator to the V-Ω and COM terminals and set its output to 0.0000V. With the Model 132 on the 200mV AC range, set R122 for a display reading of 00.0.
5. Set the calibrator output to 190.00mV, 500Hz and adjust R120 on the Model 132 for a reading of 190.0mV.
6. This concludes the voltage calibration procedure. If temperature calibration is to be done, proceed to the next section. Otherwise, install the switch cover and replace the rear cover on the instrument.

Temperature Calibration

1. Construct a thermocouple with a miniature TC plug as shown in Figure 7. Plug the connector end into the instrument.
2. Make up an ice water bath by firmly packing a Dewar flask or thermos with pea-size ice cubes and then fill the flask with distilled water. Replace the melted ice with new ice while removing excess water during the calibration procedure.
3. Drill a hole in the flask or thermos cap just large enough to accomodate the thermocouple wire. Place the cap on the flask and pass the thermocouple wire through the hole until the junction rests in the center of the volume of ice and water.
4. Allow 20 minutes for the test fixture temperature to stabilize. With the Model 132C in the °C and TEMP modes, adjust R126 for a reading of 000 on the display. The Model 132F reading should be 032 for the same adjustment.

Table 4. Calibration Summary

Calibration Value	Model 132 Function and Range	Terminals	Adjustment	Desired Reading
190.00mV DC	200mV DC	COM, V-Ω	R108	190.0
0.000V	200mV AC	COM, V-Ω	R122	00.0
190.0mV AC, 500Hz	200mV AC	COM, V-Ω	R120	190.0
0°C* (Ice Water)	°C, TEMP	Thermocouple	R126	000*
32°F**	°F, TEMP	Thermocouple	R126	032**

*Model 132C
**Model 132F

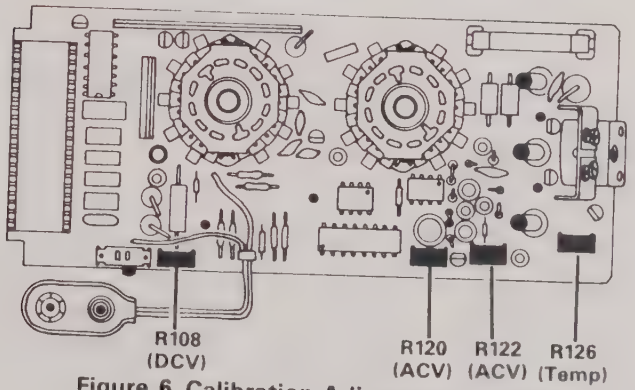


Figure 6. Calibration Adjustment Locations

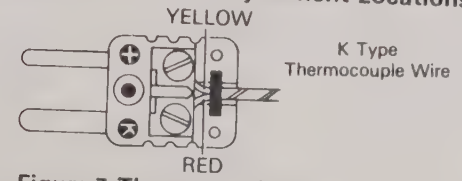


Figure 7. Themocouple Plug

HANDLING AND CLEANING PRECAUTIONS

Several areas of the Model 132 circuit board and associated components are sensitive to contamination, either by touching, or from foreign materials. In general, high impedance areas of the circuit are the most sensitive to contamination. To avoid degrading instrument performance, observe the following precautions.

1. Handle the PC board only by the edges whenever possible. Avoid touching any components not directly associated with the repair.
2. If the instrument is operated in dusty environments, dust could build up on the PC board and components. In some instances, this could affect instrument performance. Use clean, dry, pressurized air to clean the circuit board when necessary.
3. If it is necessary to use solder on the circuit board, completely remove the flux from the board when the repair is complete. Use the proper flux remover, but avoid spreading the flux and remover into other areas of the board. Cotton swabs or a soft brush dipped in flux remover may be helpful (do not get the flux remover on the switch contacts). Any flux left on the board, especially in high impedance areas, could degrade performance.
4. Once all flux is removed, clean the repaired area and other contaminated areas with a cotton swab or soft brush and demineralized water. Dry with clean, dry, pressurized air, then bake for five hours at a temperature of 50°C. The board should be removed from the case before washing; do not reassemble before completely dry.
5. Do not allow the LCD display to get wet. Do not touch contact areas on the display, elastomer strip connector, or PC board.

TROUBLESHOOTING GUIDE

The following troubleshooting information is intended for use by qualified electronics maintenance personnel who are thoroughly familiar with the proper use of standard electronic test equipment. Use the parts list, schematic, and component layout drawing as an aid in identifying components.

To gain access to the PC board, partial disassembly of the instrument is required, as described in the disassembly instructions. When working with the PC board, take care not to touch the PC board traces or ceramic range resistor network; otherwise, contamination could occur, degrading instrument performance. Avoid the use of foreign substances such as spray-on contact cleaner which could also cause contamination of sensitive areas.

Tables 5 through 8 contain troubleshooting information. To use these tables proceed as follows:

1. Table 5 contains a number of DC voltage checks that can be made throughout the instrument. Most voltages are referenced to analog common which is connected to the COM jack. All voltages are checked with no signal applied to the instrument.
2. Table 6 shows resistance measurements that can be made from the input jacks to check the accuracy of the range and current shunt resistors. These checks should be made with the power turned off.
3. Table 7 shows checks to be made with an accurate signal applied to the V-Ω and COM terminals. To perform each check, apply the indicated signal and switch the Model 132 to the required range. Then measure the signal at the indicated point. All the voltages listed in Table 7 are referenced to analog common.
4. Table 8 shows waveforms to be checked on a number of A/D converter pins (U101). Note that these waveforms are referenced to digital common, which is located on pin 4 of U101.

Table 5. DC Voltage Checks

Step	Item/Component	Required Condition	Remarks
1		Turn on power, select 1000V DC range.	All voltages referenced to analog common unless otherwise noted (COM terminal).
2	Battery + and − terminals.	> 7.2V DC	Depends on battery condition.
3	Battery + terminal to COM.	2.4-3.2V DC	
4	Battery − terminal to COM.	−6.2V DC	Depends on battery condition.
5	CR101 cathode	+1.20V-1.23V	Reference source.
6	U101, pin 40	4-6V	Referenced to digital common (U101 pin 4).
7	U105 pin 3	2.4-3.2V DC	Depends on battery condition.
8	U106 pin 1	+2.1V DC ± 20%	With thermocouple not plugged in.
9	U106 pin 1	−5.5V DC	With thermocouple plugged in (will vary with battery voltage).

Table 6. Resistance Checks

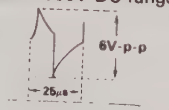
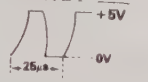
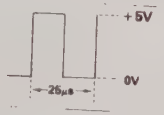
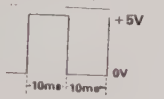
Function and Range	Measure Between	Normal Reading	Remarks
1000V DC	V-Ω and COM	10MΩ ±0.5%	If different, check R112, R117
2000mA DC	mA and COM	0.4Ω	Current shunt. If different check R109, R107 and S102C (will show open if fuse is bad).
200mA DC	mA and COM	1.3Ω	
20mA DC	mA and COM	10.2Ω	
2mA DC	mA and COM	100.2Ω	

Table 7. Signal Tracing Checks

Function and Range	Applied Signal	Measured Point	Required Reading	Remarks
200mV DC	190mV DC	Top of R105	190mV DC*	A/D Converter Input
2V AC	1.9V AC RMS, 500Hz	U105 pin 4	190mV AC RMS	TRMS Converter Input
2V AC	1.9V AC RMS, 500Hz	U105 pin 10	190mV DC	TRMS Converter Output
200mV AC	190mV AC RMS, 500Hz	Top of R105	190mV DC*	A/D Converter Input

*Will read about 1% low with a meter with 10MΩ input resistance.

Table 8. Waveform Checks

Step	Item/Component	Required Condition	Remarks
1		Turn on power and select 1000V DC range.	Waveforms measured with respect to digital common (U101 pin 4). A/D Clock
2	Pin 1 U101		
3	Pin 2 U101		A/D Clock
4	Pin 3 U101		A/D Clock
5	U101 pins 16-19, 23-39		LCD segment drive pulses.
6	U101 pin 14		Integrator waveform. (Requires full range input. Example: 1.9V DC on 2V DC range.)

PARTS LIST

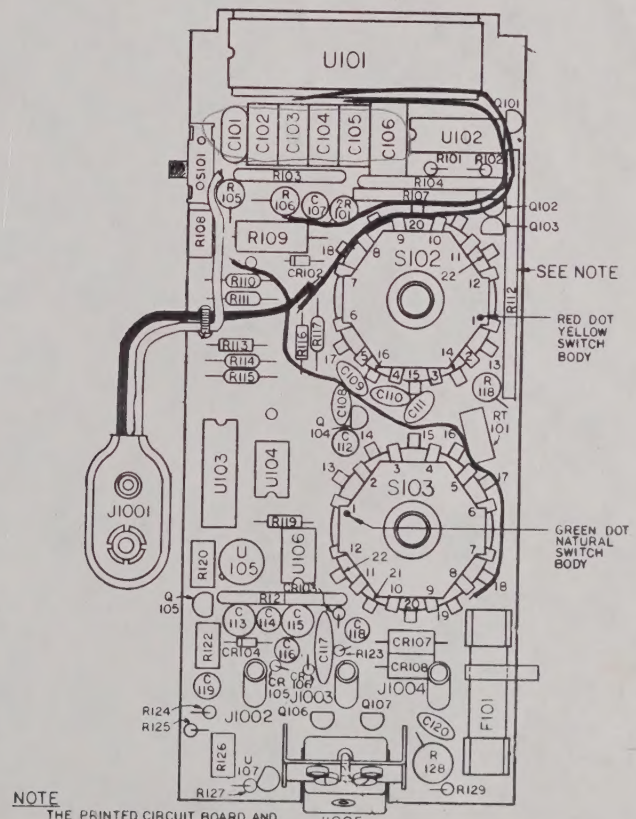
Circuit Desig.	Description	Schematic Location	Keithley Part No.
BT101	Battery, 9V, NEDA 1604	C5	BA-14
C101	Capacitor, 110pF, 500V, 1%, Mica	H3	C-278-110p
C102	Capacitor, .22μF, 100V, Polyester	G3	C-305-.22
C103	Capacitor, .047μF, 100V, Polyester	F3	C-305-.047
C104	Capacitor, .047μF, 100V, Polyester	F4	C-305-.047
C105	Capacitor, .22μF, 100V, Polyester	H3	C-305-.22
C106	Capacitor, .1μF, 100V, Polyprpolene	H3	C-306-.1
C107	Capacitor, 4.7μF, 25V, Aluminum Electrolytic	G1	C-314-4.7
C108	Capacitor, 100pF, 1000V, Ceramic Disk	C3	C-64-100p
C109	Capacitor, .022μF, 16V, Ceramic Disk	A2	C-340-.022
C110	Capacitor, 1500pF, 600V, Ceramic Disk	B2	C-341-1500p
C111	Capacitor, 100pF, 1000V, Ceramic Disk	B2	C-64-100p
C112	Capacitor, 680μF, 25V, Aluminum Electrolytic	D5	C-314-6.8
C113	Capacitor, 33μF, 16V, Aluminum Electrolytic	D2	C-321-33
C114	Capacitor, 2.2μF, 16V, Aluminum Electrolytic	C2	C-325-2.2
C115	Capacitor, 33μF, 16V, Aluminum Electrolytic	D2	C-321-33
C116	Capacitor, 4.7μF, 16V, Aluminum Electrolytic	D2	C-321-4.7
C117	Capacitor, .02μF, 500V, Ceramic Disk	E2	C-316-.02
C118	Capacitor, 6.8μF, 25V, Aluminum Electrolytic	C2	C-314-6.8
C119	Capacitor, 6.8μF, 25V, Aluminum Electrolytic	D5	C-314-6.8
C120	Capacitor, 2200pF, 500V, Ceramic Disk	B4	C-22-2200p
CR102	Rectifier, 1A, 800PIV, 1N4006	D5	RF-38
CR103	Diode, Silicon, 1N4148	E2	RF-28
CR104	Diode, Silicon, 1N4148	C4	RF-28
CR105	Diode, Silicon, 1N4148	C4	RF-28
CR106	Diode, Silicon, 1N4148	E2	RF-28
CR107	Rectifier, Silicon, 3A, 50 PIV, 1N4139	B5	RF-34
CR108	Rectifier, Silicon, 3A, 50 PIV, 1N4139	B5	RF-34
DS101	LCD Display	G5	DD-27
F101	Fuse, 2A ~~Fast-Blow~~, 250V, ~~3AG~~ CERAMIC	A5	FU-~~13~~ 62
J1001	Battery Connector	C5	BH-29
J1002	V-Ω Input Jack	A1	A30300-3
J1003	COM Input Jack	A4	A30300-3
J1004	mA Input Jack	A5	A30300-3
J1005	TC Jack	A3	CS-438
Q101	Transistor, Silicon, NPN, 2N3904	F5	TG-47
Q102	Transistor, Silicon, NPN, 2N3904	H2	TG-47
Q103	Transistor, Silicon, PNP, 2N3906	H2	TG-84
Q104	Transistor, Silicon, NPN	F3	TG-138
Q105	Transistor, Silicon, PNP, 2N3906	C4	TG-84
Q106	Transistor, Silicon, NPN, 2N3904	A4	TG-47
Q107	Transistor, Silicon, NPN, 2N3904	B4	TG-47
R101	Resistor, 220kΩ, 5%, 1/4W, Composition	F5	R-76-220k
R102	Resistor, 390kΩ, 5%, 1/4W, Composition	H3	R-76-390k
R103	Resistor, Thick Film Network	G3/H3	TF-156
R104	Resistor, Thick Film Network	E6/F5	TF-155

PARTS LIST

Circuit Desig.	Description	Schematic Location	Keithley Part No.
R105	Resistor, 470Ω, 10%, 1W, Composition	E3	R-2-470k
R106	Resistor, 470Ω, 10%, 1W, Composition	E4	R-2-470k
R107	Resistor, Thick Film Network	B5	TF-94
R108	Potentiometer, 500Ω, 0.5W	G2	RP-111-5000
R109	Resistor, .1Ω, 0.5%, 1W, Wirewound	B4	R-279-.1
R110	Resistor, 4.75kΩ, 0.5%, 1/8W, Metal Film	G2	R-246-4.75k
R111	Resistor, 562kΩ, 0.5%, 1/8W, Metal Film	G1	R-246-562k
R112	Resistor, Thick Film Network	B1/B2	TF-158
R113	Resistor, 10kΩ, 5%, 1/4W, Composition	C6	R-76-10k
R114*	Resistor, 19.1kΩ, 0.1%, 1/8W	C3	R-176-19.1k*
R114**	Resistor, 21.5kΩ, 0.1%, 1/8W	C3	R-176-21.5k**
R115*	Resistor, 13kΩ, 0.1%, 1/8W	C4	R-176-13k*
R115**	Resistor, 6.19kΩ, 0.1%, 1/8W	C4	R-176-6.19k**
R116	Resistor, 100kΩ, 5%, 1/4W, Composition	F3	R-76-100k
R117	Resistor, 100Ω, 0.1%, 1/8W	B3	R-176-100
R118	Resistor, 100kΩ, 10%, 1W, Composition	A1	R-2-100k
R119	Resistor, 4.7MΩ, 10%, 1/4W, Composition	D2	R-76-4.7M
R120	Potentiometer, 500Ω, 0.5W	D2	RP-111-500
R121	Resistor, Thick Film Network	B3/C2/C3	TF-157
R122	Potentiometer, 500kΩ, 0.5W	C2	RP-111-500k
R123	Resistor, 4.7MΩ, 10%, 1/4W, Composition	B3	R-76-4.7M
R124*	Resistor, 174Ω, 1%, 1/8W	D4	R-88-174*
R124**	Resistor, 115Ω, 1%, 1/8W	D4	R-88-115**
R125	Resistor, 9.09kΩ, 1%, 1/8W	D4	R-88-9.09*
R125	Resistor, 8.45kΩ, 1%, 1/8W	D4	R-88-8.45k**
R126	Potentiometer, 5kΩ, 0.5W	D4	RP-111-5k
R127*	Resistor, 576Ω, 1%, 1/8W	C4	R-88-576*
R127**	Resistor, 499Ω, 1%, 1/8W	C4	R-88-499**
R128	Resistor, 10kΩ, 2W, Composition	A3	R-3-10k
R129	Resistor, 22MΩ, 10%, 1/4W, Composition	A3	R-76-22M
RT101	Thermistor, 1kΩ, +10%, −20% @ 25°C	F2	RT-7
S101	Switch, ON/OFF	C5	SW-417
S102	Switch, Range	Several	SW-432
S103	Switch, Function	Several	SW-433
U101	IC, 3 1/2 Digit A/D Converter, ITS 80062	G4	LSI-22
U102	IC, Quad EX-OR Gate, 4070	F5/F6	IC-226
U103	IC, Selected CD4053BC	D3/G3/D6	31847-1
U104	IC, Op AMP, 308A	C3	IC-203
U105	IC, Low-Level TRMS Converter, AD636J	D2	IC-319
U106	IC, JFET Op AMP, TL062CP	C3/D2	IC-279
U107	IC, Current Source, LM334	C4	IC-278
VR101	Zener Reference, 1.23V	C1	DZ-65

*Model 132C
**Model 132F

COMPONENT LAYOUT



NOTE

THE PRINTED CIRCUIT BOARD AND COMPONENTS SUCH AS THE PRECISION CERAMIC INPUT DIVIDER MUST BE KEPT FREE OF CONTAMINANTS. REFER TO THE INSTRUCTION MANUAL FOR PROPER HANDLING PROCEDURES.